Performance Evaluation of DSDV and AODV Protocols for Green Corridor Management in a Metropolitan City

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***Abstract*—Air pollution is a serious health concern in densely populated metropolitan cities. Vehicle traffic congestion is a major challenge, especially in medical emergency cases, such as transportation of life saving drugs, accident victims, or transplant organs. In this paper, we propose a signal free corridor based air pollution management for ambulances by maintaining proper speed in which ambulances do not encounter any signals, decreasing the vehicle density and air pollution at junctions. Performance evaluation of Destination Sequenced Distance Vector Protocol (DSDV) and Ad-Hoc On Demand Distance Vector Protocol (AODV) for the vehicular environment in multiple scenarios has been simulated and the results are encouraging**.

Keywords- AODV; DSDV; Signal free route; NS-2.

I. INTRODUCTION

Air pollution is mainly caused by fuel-wood and biomass burning, fuel adulteration, vehicle emission and traffic congestion. It is concentrated in densely populated metropolitan cities. Some of the reasons why pollution is concentrated in metropolitan areas include (1) High density of vehicles, (2) Increased number of traffic signals, (3) Increase in the number of diesel vehicles, (4) Increased number of two wheelers, (5) Decreased carpooling, (6) Reduced public transportation usage.

Bengaluru is a metropolitan city having a population of 150,000,000 [3]. As per recent statistics, the vehicle population in Bengaluru is 5,800,000, and 90% of registered vehicles are motor bikes and cars, with 1300 new vehicles getting added every day. Only 40,000,000 people use public transport services like BMTC (Bangalore Metropolitan Transport Corporation). The rest of the population uses their own vehicles. Hence, travel speed has dropped to 15 Km/h.

A. Vehicle Statistics in Bengaluru [3]

We include below some vehicle statistics in Bengaluru.

1) Two wheelers – 3,841,140
2) Light motor vehicles-1,141,460
3) Heavy truck vehicles-108,850
4) Auto rickshaws-149,950
5) Heavy goods vehicles-73,470
6) Floating vehicles-200,000
7) other vehicles-244,890

Total number of vehicles is 5,759,760.

The average speed of vehicles on many metropolitan city roads is less than 15 kilometers per hour during peak hours [3]. At such speeds, vehicles in India emit air pollutants 4 to 8 times higher than pollutants emitted when there is less traffic congestion. Indian vehicles also consume increased carbon footprint fuel per trip than in the case where traffic congestion is less. The more severe the traffic congestion, the longer vehicles stay at junctions, causing greater air pollution [1].

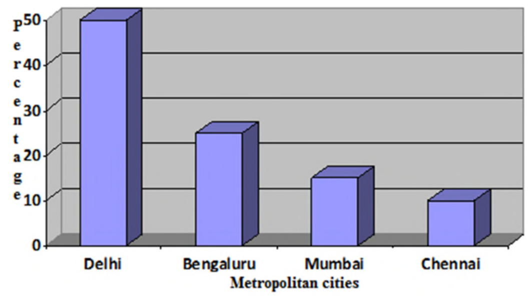

Figure 1. Air pollution levels in different metropolitan cities of India [3].

Bangalore has reported that, one in every two children of the city are suffering from bronchial related diseases, ranking second in the list of cities with highest air pollution levels in India (see Fig. 1). The annual average values of air pollutants in Bengaluru show a linear increase year after year (see Fig. 2). Ideas of road widening, one way streets, strict traffic rules, efficient navigation system can reduce congestion. Vehicles must not wait for a long time at traffic signals and, hence, signal free routes are recommended.

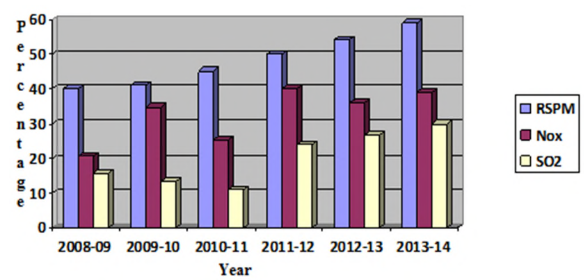

Figure 2. Annual average values of air pollutants in Bengaluru [3].

II. SIGNAL FREE ROUTE

Signal free route is a congestion free route between the source and the destination. In vehicles transport, this means no encountering of any signals of traffic by maintaining optimum speed and coordinating between vehicles on the road. There is an exponential increase in the number of vehicles on the road every day. Traffic congestion reduces average traffic speed during peak hours. At low speeds, scientific studies reveal, vehicles burn fuel inefficiently and pollute more per trip [2]. Similar to the signal free route for ambulances while transporting transplant organs, signal free routes can be designed for the Bangalore long distance routes using the DSDV and AODV protocols. These protocols show the shortest possible path between the source and the destination. To overcome the hurdles of traffic signals, proper speed has to be maintained by the vehicles. Signal free route for ambulances at the time of emergencies can also be designed using Vehicle Ad-Hoc Networks (VANET). Sensing traffic congestion on the route of an ambulance, the dispatch center communicates to vehicles on the route and thereby vehicles communicate with each other for maintaining proper speed on signal free route and giving way for the ambulances in case of emergencies.

III. VANETs

VANETs are a form of Mobile Ad-Hoc Networks (MANETs) with the mobile nodes being vehicles and it is mainly aimed at providing safety and hassle-free transportation for passengers. In these networks, vehicles are equipped with communication equipment that allows them to communicate with each other i.e., Vehicle to Vehicle (V2V) communication and also to exchange messages with a roadside network infrastructure i.e., Vehicle to Infrastructure (V2I) communication [2]. It provides an efficient way to use vehicular networking. VANETs are applied to control the high density of vehicles during congestion in metropolitan cities. They find their applications widely in electronic toll collection, monitoring, collision warning, road signal alarms, parking lot payment, and so on. Specific areas of research in VANETs include routing, broadcasting, quality of service and security [1].

VANETs are important components of Intelligent Transportation Systems (ITS) to set up communication systems in the form of location tracking using Global Positioning System (GPS), wireless networks. The need for ITS arises from the real time problems of traffic congestion, to provide a comfortable, hassle-free transportation system to the vehicles. Congestion is a major challenge for the efficiency of the transportation system, travel time, speed and fuel consumption. It has its application to retrieve information about instant accidents and traffic messages and helps in designing and developing a better traffic signaling system. It also offers multimedia applications such as Internet connectivity and multimedia access [2]. The better the management of traffic congestion on roads, the better the air pollution management.

Some of the characteristics of VANETs include [10]:

1) Highly dynamic topology,
2) Frequently disconnected network,
3) Mobility modeling and prediction,
4) Communication environment,
5) Hard delay constraints.

A. *IEEE 802.11p and IEEE 1609 Standards*

IEEE 802.11p standard [4] describes the extensions added to 802.11 that had significant overheads used in different multiple vehicular scenarios for Media Access Control (MAC) operations. 802.11p protocol operates in 5.8/5.9 GHz with a guard band from 5.850-5.855 GHz, to support ITS applications of On Board Unit (OBU) to Road Side Unit (RSU) communication. RSU to RSU communications are developed that describe the security, management and physical access in Wireless Access in Vehicular Environments (WAVE) communication. At the Transmission Control Protocol-Wi-Fi Wireless Short Message Protocol (TCP-WI WSMP) layer, Unicasting (for non-safety applications) and Broadcasting (for safety applications) are specified providing limitations in the case of low bandwidth occupancy and low power usage [1].

The IEEE 1609 family of standards for WAVE [4] describes the architecture, communication model, management structure, security mechanisms and physical access for high speed (about 27 Mb/s) and short range (about 1000m) low latency wireless communications in the vehicular environment. The primary architectural components defined by the 1609 standards are the OBU, RSU and WAVE interface. IEEE 1609.0 defines the usage of WAVE environment by applications, the respective management activities are defined by IEEEp1609.1, the security protocols are defined by IEEEp 1609.2, and the network-layer protocols are defined by IEEEp 1609.3. Additionally, the standard also provides extensions to the physical channel access defined in IEEE 802.11 to support the WAVE standards in IEEE p1609.4.

The IEEE 1609 family standards find various applications in design, specification, implementation and testing of WAVE devices used in transportation, automotive and traffic management. Network, hardware and application designers of ITS use these standards as they define the communications architecture for Dedicated Short Range Communication (DSRC) based V2V and V2I interactions, and they pose as the basis for the low-latency interface design of on-board and roadside devices. ITS application designers use the standards to deploy the basis for interface definitions between system components and as a framework for application architecture. The architecture, interfaces and messages defined in the IEEE 1609 family of standards for WAVE support the operation of secure wireless communications between vehicles and infrastructure, as well as between vehicles [9].

B. *Dijkstra's Algorithm*

The Dijkstra's Algorithm is a graph based search algorithm that gives the shortest path solution for the single source graph with positive edge costs by producing the shortest path tree. This routing algorithm finds the path of lowest cost between the source node and every other node, thereby resulting in the shortest path between source and destination. It has wide applications in network routing protocols such as Open Shortest Path First (OSPF) and is also helpful in finding the shortest distance to the destined city from a source city [2].

C. Ad-Hoc On Demand Distance Vector Protocol

The AODV algorithm is a reactive protocol whose route finding is carried out by Route Discovery Cycle (RDC) maintaining active routing. It is a descendant of DSDV protocol providing unicast and multi-cast communication and adding an extra feature of sequence number to prevent loop formation. AODV is noted for its quick adaptation under dynamic link conditions, consuming less network bandwidth, which can be scalable for large network [5].

D. Destination Sequenced Distance Vector Protocol

DSDV is a Bellman-Ford algorithm based protocol that provides solutions to routing loop problems by adding sequence numbers. DSDV provides the best performance in networks with moderate mobility and few nodes. Requiring regular update of its routing tables becomes the major setback for its performance in dynamic environments and large network [6].

E. NS-2

Network Simulator-2 (NS-2) is a well-accepted tool for network simulation, as its architecture is suitable for extensions and interfacing with other simulation modules. It can be implemented using IEEE 802.11 protocol. It is used in the simulation of routing protocols and it is highly used in ad-hoc networking research. NS-2 supports popular network protocols, offering simulation results for wired and wireless networks alike. AODV and DSDV routing protocols are used for simulation [1].

IV. PERFORMANCE EVALUATION OF GREEN CORRIDOR MANAGEMENT

Vehicles equipped with communication devices can interact effectively by exchanging information on congestion with the dispatch center and other surrounding vehicles, making it feasible for the vehicles to travel in coordination and giving way to ambulances in a signal free route. Congestion Detection Algorithms (CDA) are used to find the high traffic density areas with low vehicular speeds allowing the drivers of ambulances to reroute to any other shortest path available. RSU are deployed to transmit data during obstacles in order to restrict the exchange of data during its need from the centralized location. The information updates on congestion can be given to drivers in the form of text messages to the OBU.

Ever since the Bangalore International Airport came into existence, a number of road development projects in all parts of the city have been deployed to make the travel to the airport convenient and faster. In parallel, there is an exponential increase in the number of vehicles every day, which in turn increases congestion and air-pollution, reducing average traffic speed and causing inefficient usage of fuel by vehicles.

Bangalore has evidenced the instances of green corridor with the help of Bangalore traffic police during major life saving emergency cases. Green corridor for live heart transport from Bangalore to Chennai reduced the travel time to 2 hours from 7 hours in September 2014 [5]. Deriving the idea from this, signal free routes can be designed for the Bangalore long distance routes using the DSDV and AODV protocols depicting the less possible congestion and less air polluted path between the source and destination. Vehicles that maintain proper speed stay in the signal free route, experiencing less traffic congestion by increasing the average travel speed by at least 2 times. The air pollutants density in the vicinity of traffic signals and travel time are decreased considerably.

A. Implementation

The required aspects for the performance evaluation are:

I. Availability of sufficient VANET modules on the routes to detect congestion.
II. Existence of dispatch centre that holds the updated data, based on traffic congestion.
III. Presence of RSU helps in signal propagation during obstacles restricting propagation.
IV. Vehicles in signal free route maintain speed in the given range, as shown in Table II.

B. Case Study

1) For Public Transport:

The vehicle of interest starts from the source at Dr. Ambedkar Institute of Technology College (Dr. AIT) to reach the destination University Visvesvaraya College of Engineering (UVCE) and can go by 4 routes and achieve the shortest path with fewer signals in route. For the least air pollution, the vehicle has to travel through the route which has the least number of traffic signals that contribute to the shortest path.

1. Route 1 has 10 traffic signals.
2. Route 2 has 11 traffic signals.
3. Route 3 has 11 traffic signals.
4. Route 4 has 9 traffic signals.

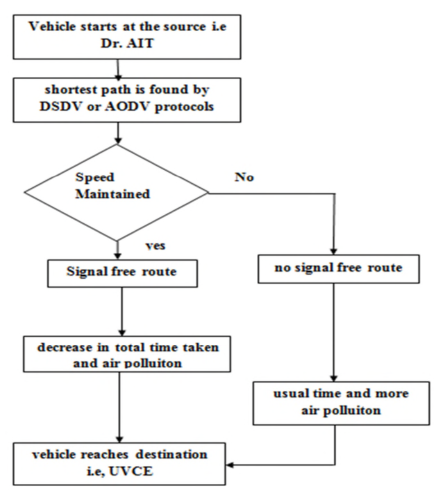

Figure 3. Flowchart for Case 1.

Since route 4 has the least number of traffic signals, the vehicle of interest travels along this route. The idea of signal free route can be implemented by taking speed, congestion, direction of traffic, duration, number of traffic signals on the route and emergency into considerations. The shortest path is found by DSDV or AODV protocol considering traffic signals as nodes traversing through the minimum number of traffic signals, and, consequently, minimal air pollution. In turn, it also increases the average speed and decreasing the time taken to reach the destination by 50% compared to the existing traffic system. The air pollutants spread over the route instead of getting concentrated in traffic junctions, as depicted in Fig. 3.

TABLE I: TABLE TO SHOW THE DISTANCE BETWEEN EACH SIGNALS, SPEED AND TIME IT TAKES TO REACH WITH THE USUAL TRAFFIC SYSTEM

From	To	*Distance*	*Speed*	*Time*
Dr.AIT	Nagarabhavi Circle	2	20	6
Nagarabhavi Circle	Chandralayout	1.2	14	5
Chandralayout	Attiguppe	0.9	18	3
Attiguppe	Underpass	3	20	9
Underpass	Rajajinagar 5th Block	1.6	16	6
Rajajinagar 5th Block	More	1.4	14	6
More	Okalipuram	0.75	15	3
Okalipuram	Majestic	1.4	8.4	10
Majestic	UVCE	3.2	17	11

TABLE II: TABLE TO SHOW THE DISTANCE BETWEEN EACH SIGNALS, SPEED AND TIME IT TAKES TO REACH WITH SIGNAL FREE ROUTE

From	To	*Distance*	*Min Speed*	*Max Speed*	*Time*
Dr.AIT	Nagarabhavi Circle	2	60	80	2
Nagarabhavi Circle	Chandralayout	1.2	36	72	2
Chandralayout	Attiguppe	0.9	27	36	2
Attiguppe	Underpass	3	45	72	4
Underpass	Rajajinagar 5th Block	1.6	48	64	2
Rajajinagar 5th Block	More	1.4	42	56	2
More	Okalipuram	0.75	22.5	30	2
Okalipuram	Majestic	1.4	28	33.6	3
Majestic	UVCE	3.2	32	38.4	6

2) For Ambulance:

The signal free route for ambulances at the time of emergency and live organ transportation is designed using VANETs, control unit and routing protocols. Considering speed, congestion, direction of traffic, duration, number of traffic signals in the route, number of ambulances in the same traffic junction, as major aspects, a green corridor is designed for ambulances. The VANETs in the path ahead of the ambulance periodically predict the possible congestion by considering the speed of surrounding vehicles and transmits the information to the surrounding nodes. In the case of vehicles traveling at a greater speed, no congestion message is transmitted but, real time congestion message is transmitted to the surrounding nodes in the case of vehicles traveling at a lower speed than that of other vehicles (nodes), enabling the ambulance to find alternate shorter paths to the nearest hospital. The unavailability of alternate route justifies the need for a signal free corridor, during which all traffic signals in the route are controlled by the ambulance, unblocking the way by signaling green. As the ambulance approaches the traffic signal within a distance of 500 m, the control of the nearest traffic signal in the route is taken over by the ambulance automatically until it is given safe passage; the ambulance is equipped with GPS and Radio Frequency (RF) module. The longitude and latitude of the traffic congested location is tracked using the GPS and the same information is updated in the database of the dispatch center. The technique of controlling traffic signal lights in signal free route consists of two units which synchronize with each other and help achieve a hassle-free travel for ambulances, Fig. 6.

The GPS installed in the ambulance unit senses the positional coordinates of an ambulance and the controller is equipped with embedded system and encoder. It predicts the direction of the ambulance using the information from the GPS receiver and transmits the same information to the decoded signal which causes the embedded system to work in emergency mode and signal green in the lane of the ambulance and red in other lanes until the ambulance crosses the junction. As soon as the ambulance crosses the junction, the embedded system starts to work in normal mode, resuming the previous conditions.

Priority will be assigned in the case of two or more ambulances in the same traffic junction, based on the distance between each ambulance and the traffic junction and the received signal strength from other ambulances. The closer the ambulance, the better the received signal strength and the higher its priority. Thereby, an efficient signal free corridor for life saving emergency cases is created.

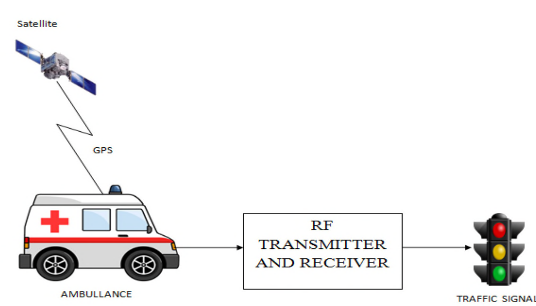

Figure 4. Proposed traffic signal monitoring system.

V. SIMULATION AND RESULTS

Experimental Analysis: To simulate the multiple scenarios of the wireless network, a TCL program is written in NS-2. The simulation related parameters are given in Table III.

TABLE III: SIMULATION RELATED PARAMETERS

Channel Type	***Wireless***
Radio-Propagation Model	Two-Ray Ground
Network Interface Type	Wireless Phy
MAC Type	Mac/802.11
Interface Queue Type	Queue/Drop Tail/Pri Queue
Antenna Model	Antenna/Omni
Link Layer Type	LL
Max packet in ifq	50

Case 1) The nodes serve as traffic signals at respective places alternating red, yellow and green color. Mobile nodes with black, brown, cyan, serve as vehicles. The node numbered 41 is the vehicle of interest and moves from source to destination, traversing a minimum number of traffic signals in the signal free route and maintaining the speed in proper range. The routing protocol used is DSDV resulting in a minimum number of packet loss, Fig. 5.

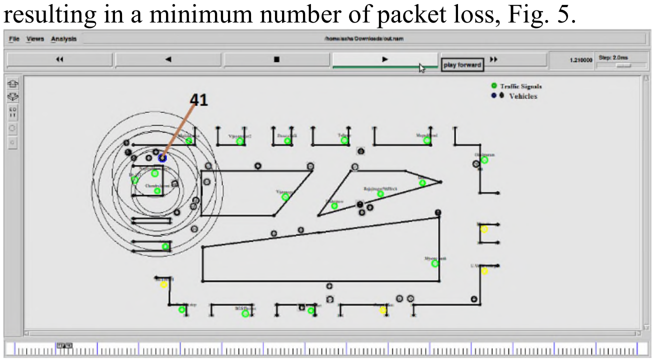

Figure 5. Signal free route using DSDV protocol.

The nodes representing traffic signals at respective places alternate red, yellow and green color. Mobile nodes with black, brown, cyan, act as vehicles. The node numbered 41 is the vehicle of interest, moves from source to destination traversing a minimum number of traffic signals in signal free route maintaining the speed in proper range. The routing protocol used is AODV resulting in an increased number of packet loss compared to DSDV, Fig. 6.

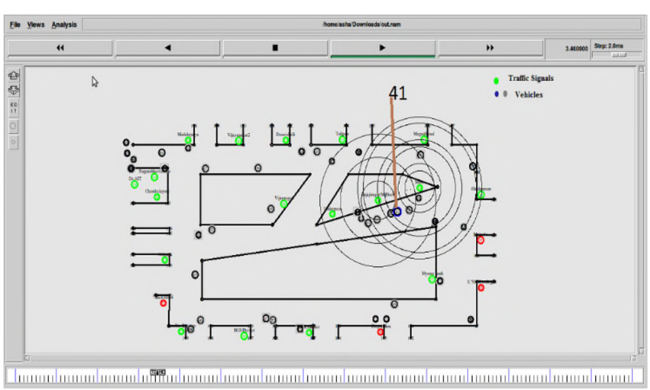

Figure 6. Signal free route using AODV protocol

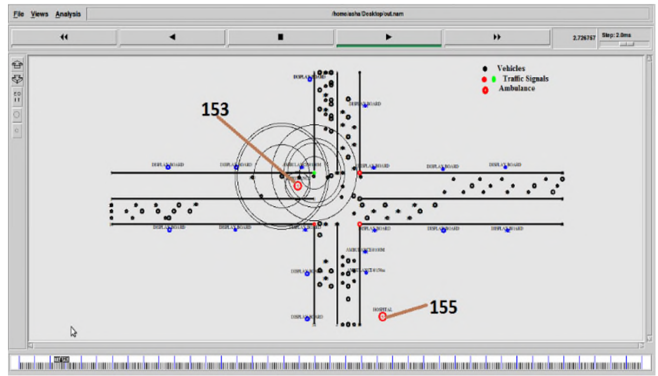

Figure 7. Signal free route in case of single ambulance.

Case 2) In case of an ambulance, considering a traffic junction with 4 lanes, blue nodes represent display board, 4 traffic signals, each for respective lanes alternating red, yellow, green color, red color. The node numbered 153 is an ambulance and the node numbered 55 represents a hospital. Knowing the positional co-ordinates of the ambulance, the display board displays the distance at road sides, vehicles ahead of the ambulance give way for it, and the RF transmitter in ambulance controls the traffic signal, Fig. 7.

In case of two or more ambulances, the nearest ambulance to the traffic junction and the highest signal strength received by the RF receiver is given highest priority. The nodes numbered 111 and 153 are ambulances destined to reach node 155, the hospital. Ambulance 111, being closer to the traffic junction than 153, impacts to signal green for 111 lane first and finally to 153, Fig. 8.

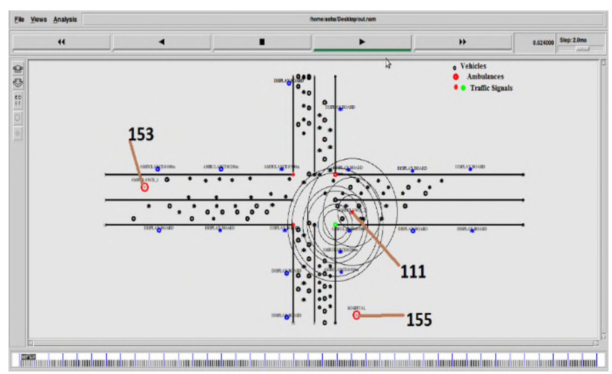

Figure 8. Signal free route in case of two or more ambulances.

The idea of signal free route for air pollution management has been simulated using both DSDV and AODV protocols for various scenarios. The average speed of vehicles on the road has doubled compared to the existing traffic system (Fig. 9) and the average travel time has decreased to half the usual travel time; the usual travel time and speed is as mentioned in Table I. Fig. 10 depicts decreasing the air pollution at traffic junction areas at least by 2 times.

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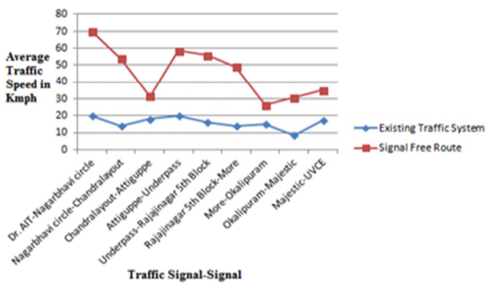

Figure 9. Comparison of existing traffic system and signal free route with respect to average traffic speed.

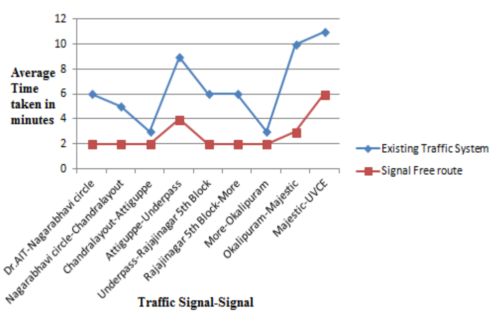

Figure 10. Comparison of existing traffic system and signal free route with respect to average time taken to reach next signal.

VI. Advantages and Disadvantages

Some of the advantages of the system include: a decrease in air pollution and a decrease in the average time taken to reach the destination by increasing the average traffic speed. It is an efficient method for ambulances and other emergency vehicles.

Among the shortcomings of the system, we can list: the probability of increase in road accidents due to increase in average traffic speed and uncoordinated vehicles on road.

VII. Conclusion

This paper aims at managing air pollution in metropolitan cities by creating signal free route reducing congestion at traffic junctions. Vehicles move in co-ordination with each other on a signal free route and maintain a proper speed, increasing the average speed of vehicles on the road. The vehicles with average speed more than 30kmph burn fuel efficiently which results in reduction of air pollution by at least 2 times. The DSDV and AODV protocols predict the least congested traffic route. The signal free route for ambulances at the time of emergencies is designed using VANETs and automatic control of traffic signal lights, resulting in a hassle-free transportation for ambulances. The idea of signal free route can be extended to other emergency vehicles like Vehicles with Z cross security, cash van, fire engines, etc., decreasing the average travel time. In the future, the idea of signal free route can be extended to other emergency vehicles like VIP, cash van, fire engines, etc., decreasing the average travel time. In order to decrease injuries from road accidents, a rule of compulsory wearing of seat belts for all passengers in the vehicles becomes necessary.

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